AN ARCTIC OIL RAILWAY

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INTRODUCTION

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In the Spring of 1971, the Canadian Institute of Guided Ground Transport initiated an engineering, economic and environmental feasibility study of a railroad to carry Arctic oil to market. This study was later expanded to include the transportation of liquid natural gas. The study was prompted by an earlier preliminary analysis by the Transportation Research Institute at Carnegie-Mellon University [1].

With cooperation from Carnegie-Mellon, Canadian National Railways, Canadian National Telecommunications, PROCOR Ltd., Canadian Pacific and Catalytic Enterprises Ltd., sixteen professionals associated with CIGGT completed the oil transportation feasibility study. Several of them are currently working on the detailed design of this system and the Liquid Natural Gas Study. The Summary Report, Railway to the Arctic [2], was released in June 1972 and since that time some of the more detailed material has been revised into report form [3], [4], [5], [6], and [7].

SYSTEM DESIGN

Contrary to popular opinion, the capacity of a railway to move oil and natural gas is much greater than that of the largest (48 inch) pipeline now available. Two million barrels daily, the maximum possible flow of a 48 inch pipeline, would fill some 20 trains, well under the capacity of a single track rail system. In this study, it was decided to design and cost a double

a real barrier to soy, caribou mov't

tracked system because of advantages in operating economy, ease of maintenance and system reliability.

The most economical system design appears to consist of an 1100 mile rail line to a terminal in the vicinity of the Alberta/N.W.T. border, the southern limit of the permafrost. This permafrost is the principle barrier to conventional buried pipeline technology. From this point, conventional large diameter pipelines would connect with the existing continental distribution network in the vicinity of Edmonton. For comparison purposes, the system was designed and costed on the basis of Prudhoe Bay oil and gas supplies.

ENVIRONMENTAL IMPACT

Some disruption of the environment is inevitable no matter what mode is used to transport Arctic oil to market. The real environmental question to be resolved is: which mode of transport, and which route, can permit the required movement of oil, at acceptable economic cost, within an acceptable time period, with minimum environmental cost, and with the best long term results for the peoples who now live in and around the affected areas?

The primary problem with oil pipelines in the Arctic is that they must operate at high temperatures, 150 to 180 degrees. Buried pipelines cannot be insulated to prevent permafrost melting under such conditions. Elevated pipelines are expensive and pose new environmental problems.

A railway is not hot and accordingly need not melt the permafrost. The thick surface layer of crushed rock ballast is good insulation and thus it is easier to prevent ground damage than is possible either for a pipeline or even a road. Because a railroad can "build its own embankment" and the train

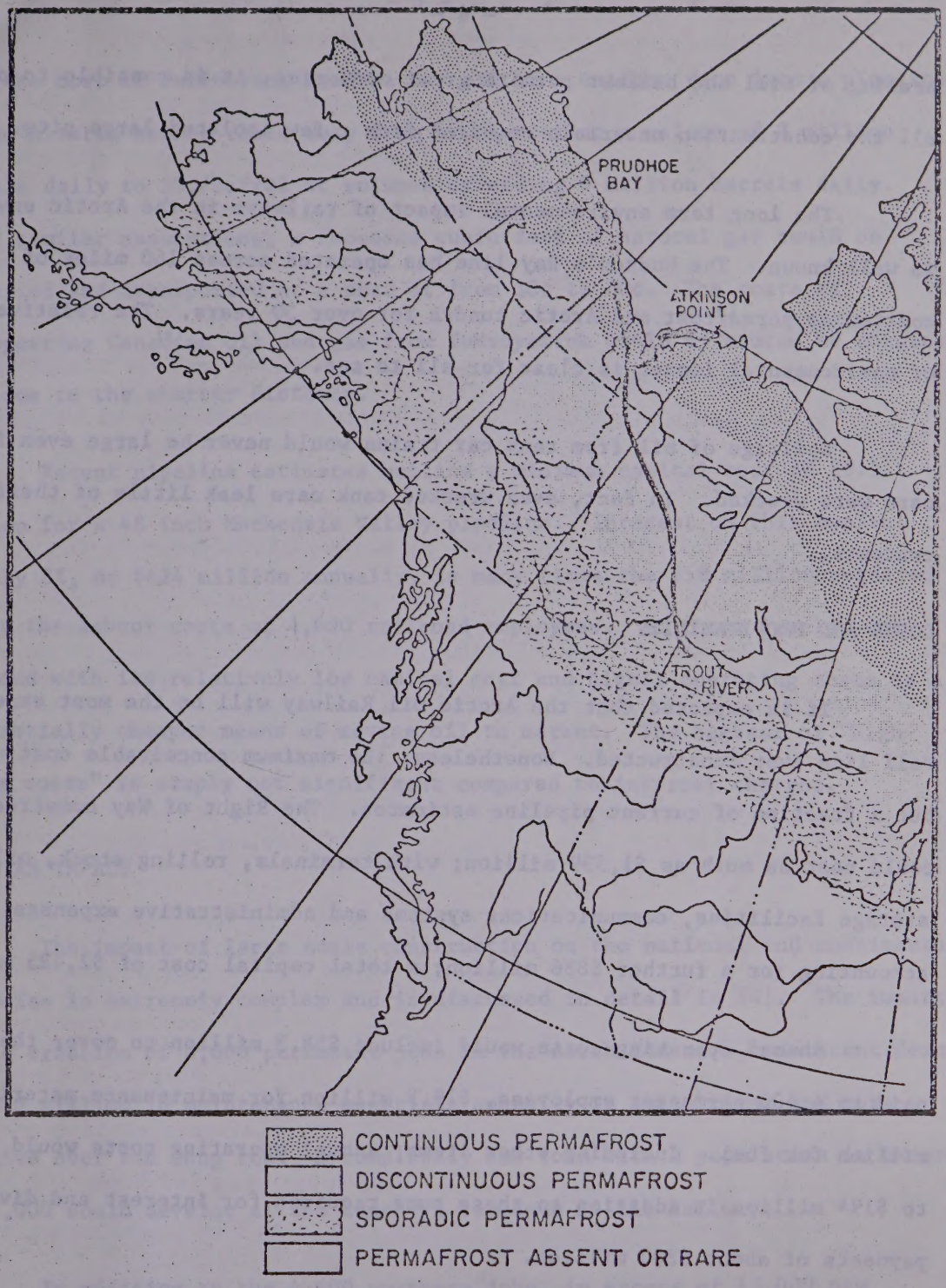

Fig. 3. Approximate Limits of Continuous and Discontinuous Permafrost Zones, Western North America.

hauling of fill and ballast permits great economies, it is possible to obtain all the construction materials required from a few isolated large pits.

The long term environmental impact of railways in the Arctic environment is well known. The Hudson's Bay line has operated across 160 miles of continuous permafrost and Arctic tundra for over 30 years. The relative lack of environmental impact is clear for all to see.

Spillage of oil from tank car trains would never be large even if many cars were wrecked. In fact, even wrecked tank cars leak little of their contents.

COSTS AND PROFITABILITY

It is expected that the Arctic Oil Railway will be the most expensive rail line ever constructed. Nonetheless, the maximum conceivable cost will be but a fraction of current pipeline estimates. The Right of Way construction could cost as much as $1,539 million; with terminals, rolling stock, oil storage facilities, communications systems and administrative expenses accounting for a further $886 million; a total capital cost of $2,425 million.

Annual operating costs would include $58.3 million to cover the salaries paid to 4,600 permanent employees, $79.5 million for maintenance materials and $47 million for fuel. Including other items, annual operating costs would amount to $194 million in addition to those sums required for interest and dividend payments of about $200 million.

Because, with relatively minor capital additions, a railway can move several times the capacity of a 48 inch pipeline, the oil shipping cost varies considerably with the volume of oil carried. If the full capital cost of the system is to be borne by the oil traffic (not shared by other commodities, for example liquid natural

gas) the cost of delivering Prudhoe Bay oil at a uniform rate into a pipeline at the Alberta border would vary from 67¢/barrel at a volume of 2 million barrels daily to 50¢/barrel at volumes exceeding 6 million barrels daily. Under similar assumptions, a thousand cubic feet of natural gas could be liquefied and transported at a cost of from 30¢ to 80¢. The costs of transporting Canadian oil and gas from Tuktoyaktuk would of course be considerably less due to the shorter distance.

Recent pipeline estimates outline a minimum capital cost of $5.3 billion for a 48 inch Mackenzie Valley pipeline. Interest on this capital at only 8%, or $424 million annually, is many times the $58 million required to pay the labour costs of 4,600 railroad employees. At these levels, the railroad with its relatively low capital cost and higher operating costs is a substantially cheaper means of moving oil to market. The bugbear of "high labour costs" is simply not significant compared to interest charges.

CANADIAN IMPACT

The impact of large scale construction on the national and continental economies is extremely complex and is discussed in detail in [4]. The impact of the creation of 4,600 permanent jobs in the north and of a consistent demand for $80 million in maintenance materials annually is quite clear and more positive over the long run. A completely new town with a population in excess of 25,000 would develop at the southern terminus of the railway.

In addition to the 4,600 northern jobs, in excess of 13,000 new permanent positions would be created in the southern regions of Canada with an additional number in the United States. The total effect of the job creation should be several times this figure.

The effects that a rail system, built to transport oil to market, but with a great deal of excess capacity, would have on the economics of other northern development, requires little comment. Such a rail system can also deliver consumer goods, particularly fresh foods, at costs far below those possible with air, barge or road transport. Reduction of the cost of living in settlements along the Mackenzie Valley to little more than that enjoyed in the more populated regions of the country would alleviate many of the problems that northern residents face.

COST OF DELAY

In their Impact Statement on the Trans Alaska Pipeline and Tanker System, the U.S. Department of the Interior reported that: (a) TAPS would be no cheaper than a Mackenzie Valley pipeline, (b) TAPS would be more damaging to the environment, and (c) Canada would provide a safer route than the tankers from Valdez to the west coast in the event of hostilities or natural disasters.

The decision to approve the pipeline was justified primarily by concluding: (a) Canada could not possibly raise the necessary funds to ensure majority ownership in an oil delivery system, (b) TAPS could be completed much earlier than any Canadian alternative, and (c) the cost to the nation of delaying the exploitation of the Prudhoe Bay oil reserves exceeds $1 billion annually. If these conclusions were in fact true, they would present a strong argument in favour of allowing an immediate start on the construction of TAPS.

In the case of the rail alternative, the Canadian ownership question would present few problems, for at typical debt ratios, $250 million would ensure Canadian control of the projected $2.4 billion transportation system. In any event, Canadian control of a $5 billion gas pipeline would exert a substantially greater strain on the nation's finances

The Department's conclusion regarding a $1 billion annual cost of delay was based on a theoretically acceptable model but several unrealistic assumptions:

(a) the delivered cost to Los Angeles of Middle-East oil will remain constant at present levels at least until 1995.

(b) the cost of production and transportation to Los Angeles of Prudhoe Bay oil will not increase above present levels.

(c) oil reserves retained for the future should be discounted at a high rate, and are thus worthless.

(d) the risk of disruption in the supply of Middle-East oil is no greater than for American oil.

All of these presumptions are clearly untrue, and their combined effect on the output from the model is astounding. In fact, given the currently rapid escalation in the price of Middle-East oil, and the unstable political climate there, there is an annual benefit from limited delay in the exploitation of Prudhoe Bay oil that is of the order of $500 million.

Exploitation will lead to the depletion and the eventual exhaustion of continental oil and gas reserves. The seriousness of this fact of life is accentuated by the realization that the total Alaskan reserves would replace imports for only two years if consumed at the rate of the estimated 1985 deficit.

The U.S. will become increasingly dependent on foreign sources of oil even if Arctic reserves are used. Since the probability of foreign sources being cut off is unlikely to decrease as time passes, there would seem to be stategic advantage in conserving domestic reserves and in continuing to use foreign supplies while they are still available.

CANADA'S BARGAINING POSITION

For every barrel of oil produced at Prudoe Bay, a thousand cubic feet of solution natural gas are released. It may be possible to reinject this gas for a period of a few months, but certainly no longer than a year. According to the United States Department of the Interior, the only practical means of transporting this gas is through Canada; and it must be transported.

The significance of this state of affairs from a Canadian point of view is the strength of this nations bargaining position. Even the Trans-Alaska Pipeline and Pacific tanker route is not beyond the influence of the Canadian government.

It is clear that Canada would be well advised to use her control to retard the pace of Arctic resource development. Not only is time required for the consideration of vital environmental and social problems and the selection of an advantageous route/mode combination, but facility construction would bestow more economic benefits at less social and environmental cost if haste is avoided.

All of these conclusions deal primarily with Prudhoe Bay Alaskan oil and its exploitation. At the moment, that is the only oil field with sufficient proven oil reserves to justify early development. But some oil, and substantial gas reserves, have already been identified in the Mackenzie Delta. It is probable that more extensive reserves will be found in the Delta and other parts of the Mackenzie Valley. The questions regarding transportation of these products are closely related to those concerning Prudhoe Bay oil and gas. It would be foolish if Canada did not consider the joint implications of these developments. While rapid exploitation of her resources may not be in Canada's best interest, it would be particularly foolish to delay research and planning until our own needs are urgent and

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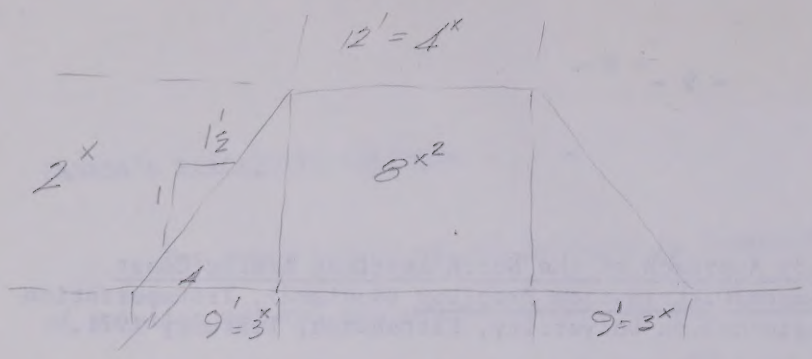

$\frac{1}{2} \times 3^x \times 2^x = 3^{x^2}$

Total x-sect area = 14 yd^3 i.e. 14 yd^3 per lineal yd.

1760
14
7040
1760
24,640 yd^3 per mile @ \$20/yd^3 = \$492,800

① pdc \$500,000/mi ≡ \$0.5 × 10^6/mi for gravel only

steel at \$400/ton

130 lb rail = 260 lb/yd for both rails

$\frac{1.3}{260} \times 1760 = 228.8$ tons/mi

② ∴ cost = \$91,520/mi for rail

pay \$100,000/mi " "

③ Ties @ 22" c to c = $\frac{480}{5280 \times 12} \times 6$ ties/mi = 2880

@ ~\$10/tie approaches \$30,000/mi

\$630,000/mi

for 1000 mi = \$630,000,000 = \$630 × 10^6

no bridges, terminals, switches etc

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LAKE

LAKE, R.w. et al.
An Arctic Oil Railway